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Characterizing the Initial Phase of Epidemic Growth on some Empirical Networks

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Abstract

A key parameter in models for the spread of infectious diseases is the basic reproduction number R_0, which is the expected number of secondary cases a typical infected primary case infects during its infectious period in a large mostly susceptible population. In order for this quantity to be meaningful, the initial expected growth of the number of infectious individuals in the large-population limit should be exponential.

We investigate to what extent this assumption is valid by performing repeated simulations of epidemics on selected empirical networks, viewing each epidemic as a random process in discrete time. The initial phase of each epidemic is analyzed by fitting the number of infected people at each time step to a generalised growth model, allowing for estimating the shape of the growth. For reference, similar investigations are done on some elementary graphs such as integer lattices in different dimensions and configuration model graphs, for which the early epidemic behaviour is known.

We find that for the empirical networks tested in this paper, exponential growth characterizes the early stages of the epidemic, except when the network is restricted by a strong low-dimensional spacial constraint, such as is the case for the two-dimensional square lattice. However, on finite integer lattices of sufficiently high dimension, the early development of epidemics shows exponential growth.

Keywords - Epidemics, Exponential growth, Generalized growth model, Reproduction number, Stochastic processes.